Use R for Climate Research

Research & Teaching Hurricane Climatology with R

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James B. Elsner
Thomas H. Jagger
Florida State University
Climatek, Inc

Summary

We use existing packages to help answer important questions about climate change (quantreg).

We develop and maintain our own scripts from bits and pieces of other packages for our students and our clients (HurRisk).

We develop teaching and research resources for our students and our clients (Use R for Climate Research).

```
par(las=1,mgp=c(2,0.5,0),tcl=-0.3,mar=c(5,5,4,2))

x=boxplot(GTC$Wmax~as.factor(GTC$Year),plot=F)

boxplot(GTC$Wmax~as.factor(GTC$Year),xaxt="n",
    ylim=c(10,86),xlab="Year",ylab="Maximum Wind
    Speed (m/s)",main="")

xx=1:26
abline(lm(x$stats[5,]~xx),col="blue",lty=1,lwd=1.5)
abline(lm(x$stats[4,]~xx),col="green3",lty=1,lwd=1.5)
abline(lm(x$stats[3,]~xx),col="red",lwd=1.5)
mtext("a",side=2,padj=-11,line=1.5,cex=1.1)

axis(1,at=seq(1,26,5),labels=seq(1981,2006,5))
axis(1,at=seq(1,26,2),labels=table(GTC$Year)[seq(1,26,2)],
    line=-2,tick=F,cex.axis=0.7)
axis(1,at=seq(2,26,2),labels=table(GTC$Year)[seq(2,26,2)],
    line=-1.5,tick=F,cex.axis=0.7)
```
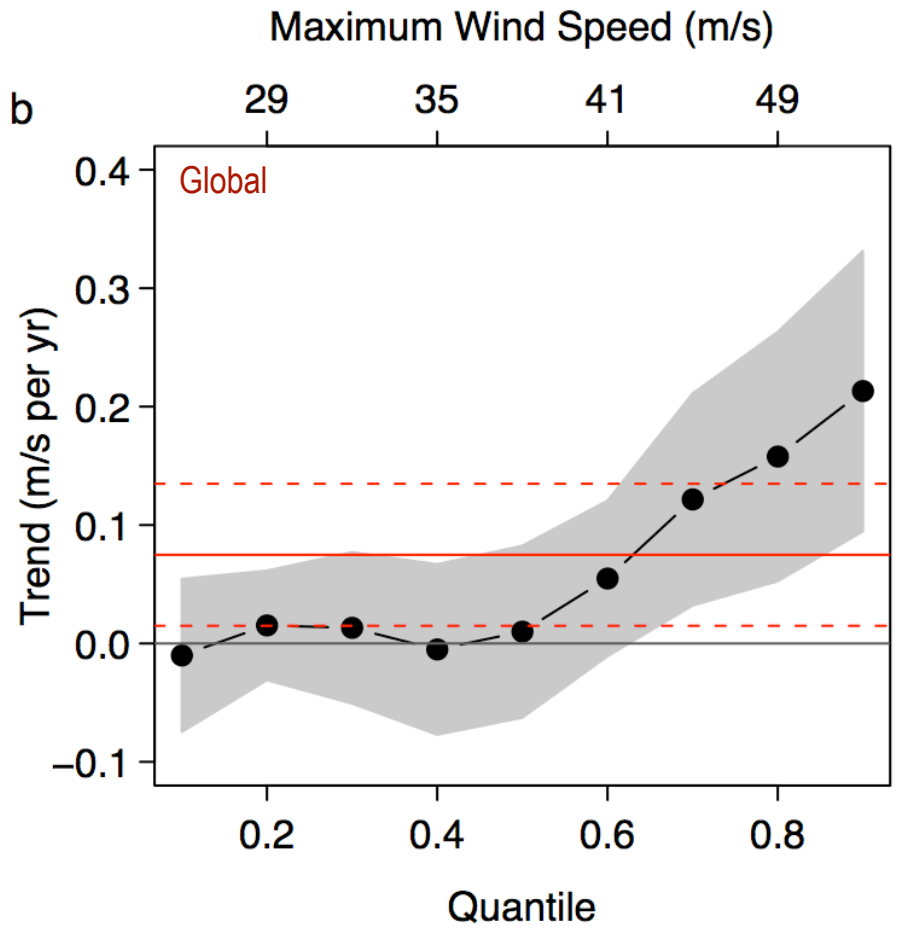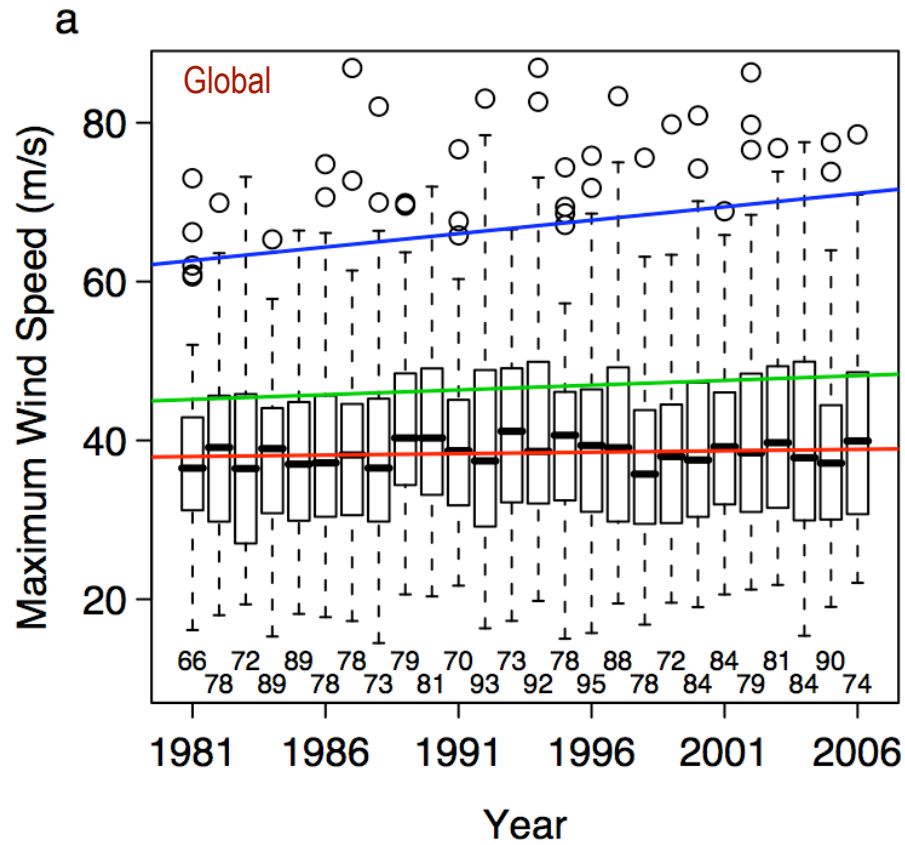
```
model.qr=rq(GTC$Wmax~GTC$Year,tau=seq(0.1,0.9,0.1))

par(las=1,mgp=c(2,0.5,0),tcl=-0.3)

plot(summary(model.qr,alpha=.05,se="iid"),xaxt="n",
    ylim=c(-0.1,0.4),mar=c(5,5,4,2)+0.1,parm=2,pch=16,
    cex=1.1,ylab="Trend (m/s per yr)",xlab="Quantile",main="")
axis(3,at=seq(0.2,0.8,0.2),labels=round(quantile(GTC$Wmax,seq
    (0.2,0.8,0.2))))
mtext("Maximum Wind Speed (m/s)",side=3,line=2)

mtext("b",side=2,padj=-11,line=1.5,cex=1.1)
```

Quantile regression of satellite-derived lifetime maximum wind speed on year

Download the HurRisk.zip file from
http://garnet.fsu.edu/~jelsner/www/forecasts.html
Unzip the file to create a directory called HurRisk

For all platforms: setwd("HurRisk")

Make sure you have the ismev, maps and foreign packages.
Copy/paste the following code

```
require(foreign); require(ismev); require(maps)
load("data/best.use.R")
load("data/landGrid.R")

source("funs/selectData.R")
source("funs/ismevplus.R")

test0=HurRisk(r=200,distunits="nm",velunits="kt",field="Wmax"
,threshold=64)
test1=HurRisk(r=250,distunits="km",velunits="m/s",field="Wma
xS",threshold=32)
```
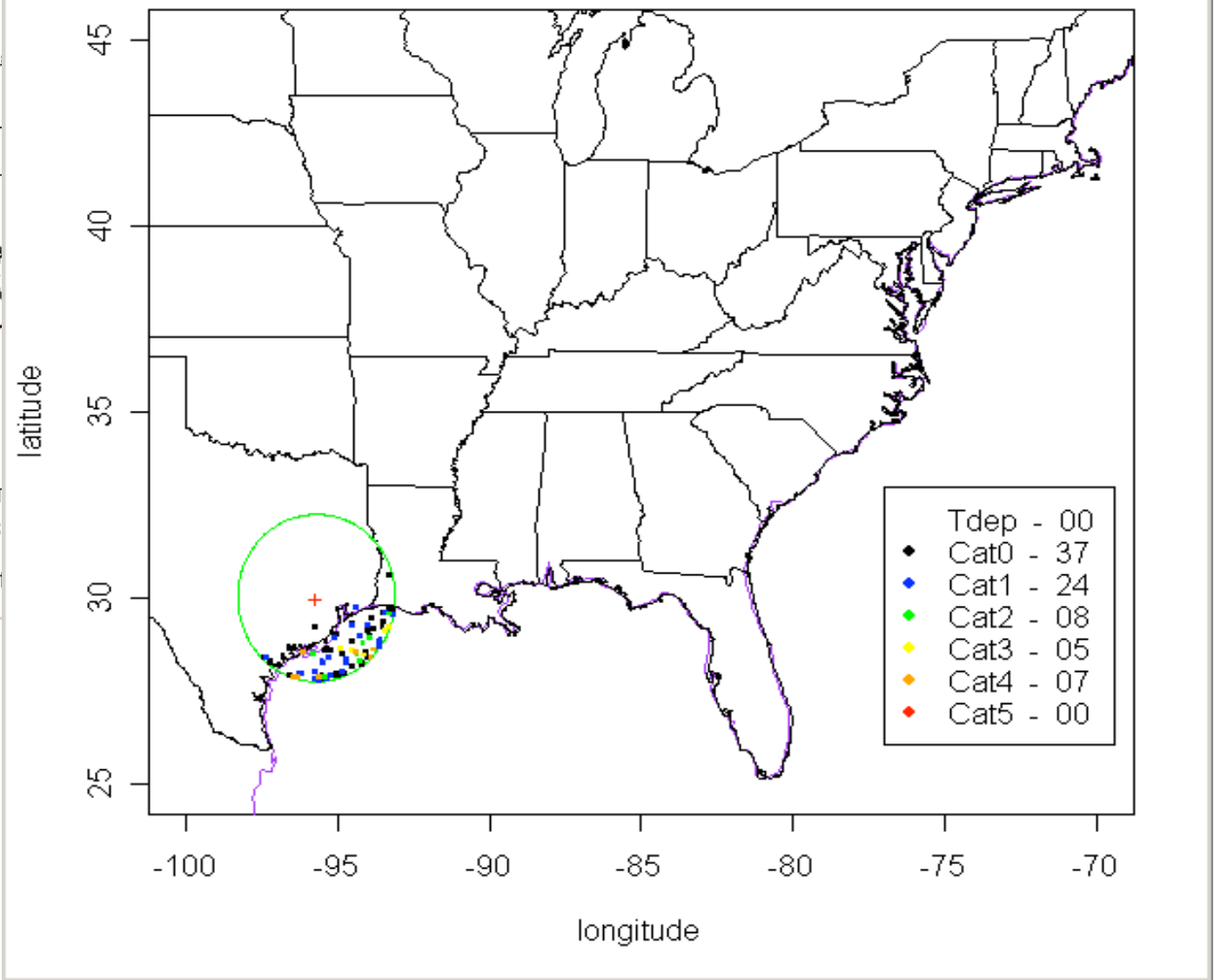
R Graphics: Device 4 (ACTIVE)

Select Point of Interest

latitude

longitude

R Graphics: Device 4 (ACTIVE)
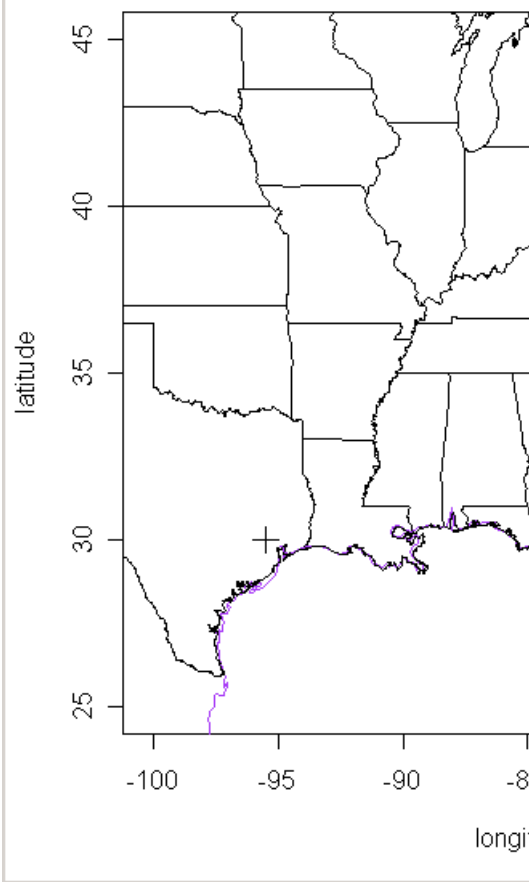
**Locations, intensities, and counts of
tropical storm maxima within selected radii**

latitude

longitude

Tdep - 00	
Cat0 - 37	
Cat1 - 24	
Cat2 - 08	
Cat3 - 05	
Cat4 - 07	
Cat5 - 00	

Return Level Plot
lon=95.7W lat=30.0N radius=250km threshold=32m/s
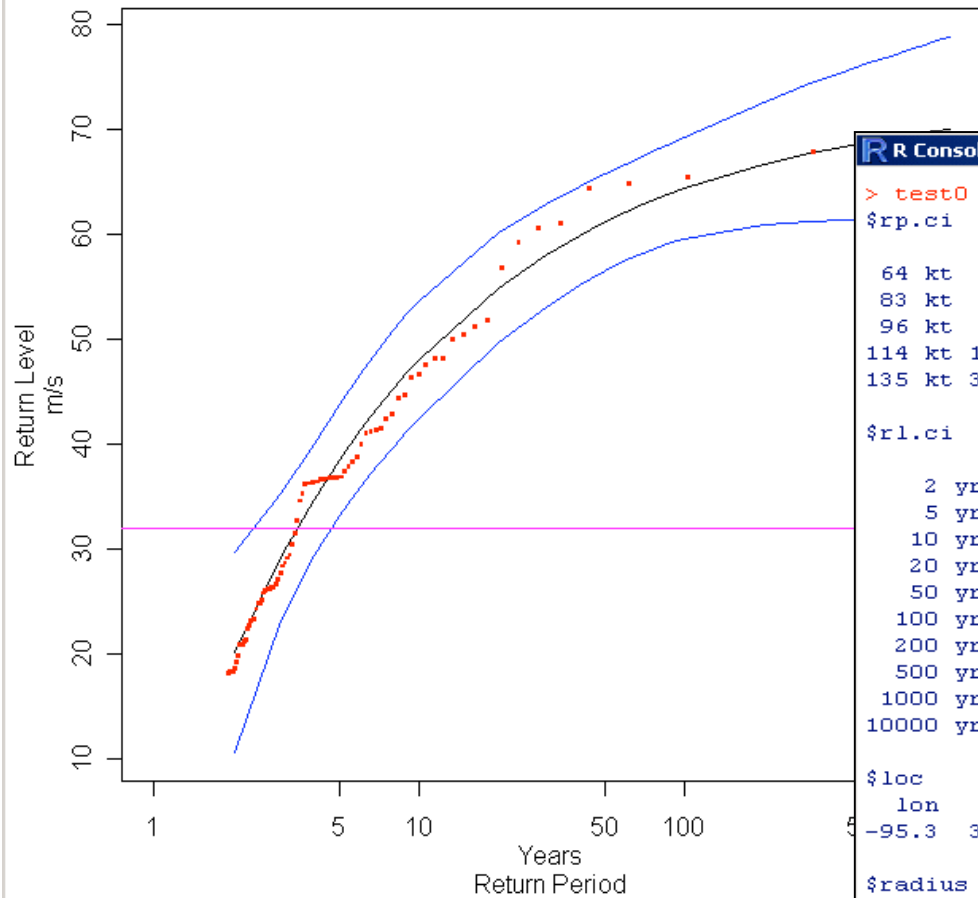
```
> test0
$rp.ci
          2.5%     5%    10%    25%    50%     75%     90%      95%  97.5%
 64 kt    1.97   2.04   2.12   2.27   2.46    2.69    2.93     3.10   3.27
 83 kt    3.49   3.63   3.80   4.12   4.55    5.09    5.68     6.12   6.55
 96 kt    5.43   5.68   6.01   6.65   7.55    8.73   10.15    11.24  12.41
114 kt   11.66  12.36  13.30  15.22  18.12   22.40   28.44    33.92  40.72
135 kt   39.51  43.04  47.99  59.40  80.71  125.87  253.58   645.63    Inf

$rl.ci
           2.5%     5%    10%    25%    50%     75%     90%     95%  97.5%
    2 yr   47.4   48.9   50.6   53.5   56.7    59.9    62.8    64.5   66.0
    5 yr   76.9   78.3   79.9   82.6   85.6    88.5    91.2    92.8   94.2
   10 yr   92.8   94.3   96.1   99.1  102.3   105.6   108.6   110.4  111.9
   20 yr  105.8  107.4  109.3  112.3  115.7   119.1   122.2   124.0  125.6
   50 yr  118.8  120.5  122.5  125.7  129.3   133.0   136.2   138.2  139.9
  100 yr  125.4  127.3  129.5  133.2  137.3   141.3   145.0   147.2  149.1
  200 yr  129.6  131.8  134.4  138.8  143.6   148.4   152.7   155.3  157.5
  500 yr  132.6  135.4  138.6  144.0  150.0   156.0   161.4   164.6  167.4
 1000 yr  133.6  136.8  140.6  146.8  153.7   160.7   166.9   170.6  173.9
10000 yr  133.2  137.8  143.0  151.8  161.5   171.2   180.0   185.2  189.8

$loc
  lon    lat
-95.3   30.1

$radius
[1] 200

$threshold
[1] 64

$distunits
[1] "nm"

$velunits
[1] "kt"

$years
[1] 1851 2005
```

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Use R for Climate Research

James B. Elsner & Thomas H. Jagger

This tutorial gives you an introduction to the R programming language for statistical analysis and modeling. Examples are taken from our research into hurricane climate. It was developed with support from the Florida State University, the U.S. National Science Foundation, and the Risk Prediction Initiative of the Bermuda Institute of Ocean Sciences. You should follow along with an open R session.

The key strokes are given in red font. If you're not a fast typer, they can be copied from the pdf (not from DVD) and pasted into your R session. Output from an R command is given in blue Courier New font. Questions for which answers are sought and practice problems are given in green font.

The tutorial is divided into 7 sections. We begin with some motivations for giving R a try and some information on how to download and install R on your computer. We show you how to use R as a calculator. In section 2 we show you how to enter data into R, how to query your data, and how to obtain some statistical information about your data.   In section 3 we provide some examples of using R for making inferences from correlations and differences in sample means. In section 4 we provide an introduction to using R for graphing your data. In section 5 we show you how R can be used to simulate various probability models and how to do bootstrap analysis. In section 6 we provide more advanced material on using R for statistical modeling. We consider linear regression, logistic regression, Poisson regression, quantile regression and regression trees.   In section 7 we list additional resource material.

1. Introduction

Benefits and drawbacks of R

Free, open source, runs on unix, linux, windows, and macs. Built in help system. Excellent

Done   zotero

Reading data

Most of your analyzes will be done on data that are read into R. First, determine what directory you are working in by typing:

getwd()

You can change your working directory by using the setwd() function and specifying the path.

Second, download the data (Save Link or Target As) into your working directory. The data are available here (http://garnet.fsu.edu/~jelsner/www/data.html) under hurricane landfall counts.

Third, a simple way to read data is to use the read.table function.

ushur = read.table("UShur1851-2006.txt",header=T)

If the file is read in, you should get the > prompt. Note the quotes around the file name as you are referencing a file outside of R. If you can use full path names for files. The header=T argument means there is a header record in the data (T stands for true). Data read in with the read.table function are of class data.frame. To check, type:

class(ushur)

To see if the data are what you expect, try the following commands.

names(ushur)   # list the column names, US: US hurr, MUS: major US hur, G: Gulf coast, FL: Florida, E: East coast
head(ushur) # list the first several rows
tail(ushur) # list the last several rows

The function read.table has options for specifying the separator character or characters between columns used in the native file. Alternatives to the default use of a space are sep="," and

Recent Hurricane Studies

- **Improving multiseason forecasts of North Atlantic hurricane activity**, *Journal of Climate*, v21, 1209-1219, March 2008.
- **Comparison of hurricane return levels using historical and geological records**, *Journal of Applied Meteorology and Climatology*, v47, 368-374, February 2008.
- **Forecasting U.S. insured hurricane losses**, in *Climate Extremes and Society*, Cambridge University Press, 189-208, 2008.
- **Granger causality and Atlantic hurricanes**, *Tellus*, v59A, 476-485, doi: 10.1111/j.1600-0870.2007.00244.x, July 2007.
- **Climatology: Tempests in time**, *Nature*, v447, 647-648, June 2007.
- **Evidence in support of the climate change-Atlantic hurricane hypothesis**, *Geophysical Research Letters*, v33, L16705, doi:10.1029/2006GL026869, August 2006.
- **Climatology models for extreme hurricane winds near the United States**, *Journal of Climate*, v19, 3220-3236, July 2006.
- **High frequency variability in hurricane power dissipation and its relationship to global temperature**, *Bulletin of the American Meteorological Society*, v87, 763-768, June 2006.
- **Forecasting U.S. hurricanes 6 months in advance**, *Geophysical Research Letters*, v33, L10704, doi:10.1029/2006GL025693, June 2006.
- **Prediction models for annual U.S. hurricane counts**, *Journal of Climate*, v19, 2935-2952, June 2006.
- **Estimated return periods for Hurricane Katrina**, *Geophysical Research Letters*, v33, L08704, doi:10.1029/2005GL025452, April 2006.
- **Comparison of hindcasts anticipating the 2004 Florida hurricane season**, *Weather & Forecasting*, v21, 182-192, April 2006.
- **Hurricane landfall probability and climate**, in **Hurricanes and Typhoons: Past, Present, and Future**, *Columbia University Press*, 333-353, 2004.
- **A hierarchical Bayesian approach to seasonal hurricane modeling**, *Journal of Climate*, v17, 2813-2827, July 2004.
- **Detecting shifts in hurricane rates using a Markov chain Monte Carlo approach**, *Journal of Climate*, v17, 2652-2666, July 2004.
- **Plotting early nineteenth-century hurricane information**, *EOS Transactions*, v85, May 2004.
- **Examining the ENSO-typhoon hypothesis**, *Climate Research*, v25, 43-54, October 2003.
- **Tracking hurricanes**, *Bulletin of the American Meteorological Society*, v84, 353-356, March 2003.
- **Seasonal space-time models for climate systems**, *Statistical Inference for Stochastic Processes*, v6, 111-133, 2003.
- **A space-time model for seasonal hurricane prediction**, *International Journal of Climatology*, v22, 451-465, March 2002.
- **Hurricane intensity changes associated with geomagnetic variation**, *Atmospheric Science Letters*, v2, 86-93, June 2001.
- **Trends in U.S. tropical cyclone mortality during the past century**, *The Florida Geographer*, v32, 28-37, 2001.
- **Bayesian analysis of U.S. hurricane climate**, *Journal of Climate*, v14, 4341-4350, December 2001.
- **Secular changes to the ENSO-U.S. hurricane relationship**, *Geophysical Research Letters*, v28, 4123-4126, November 2001.
- **A dynamic probability model of hurricane winds in coastal counties of the United States**, *Journal of Applied Meteorology*, v40, 853-863, May 2001.
- **Spatial variations in major U.S. hurricane activity: Statistics and a physical mechanism**, *Journal of Climate*, v13, 2293-2305, July 2000.
- **Changes in the rates of North Atlantic major hurricane activity during the 20th century**, *Geophysical Research Letters*, v27, 1743-1746, June 2000.
- **Global tropical cyclone activity: A link to the North Atlantic oscillation**, *Geophysical Research Letters*, v27, 129-132, January 2000.
- **Fluctuations in North Atlantic hurricane frequency**, *Journal of Climate*, v12, 427-437, February 1999.
- **Multi-year prediction model of North Atlantic hurricane activity**, *Meteorology and Atmospheric Physics*, v68, 43-51, 1998.
- **The 1995 and 1996 North Atlantic hurricane seasons: A return of the tropical-only hurricane**, *Journal of Climate*, v11, 2062-2069, August 1998.
- **Seasonal prediction models for North Atlantic basin hurricane location**, *Monthly Weather Review*, v125, 1780-1791, August 1997.

Hurricane Climatology: A Bayesian Approach

- Imperfect data in an uncertain world, June 2005.
- Over dispersion in coastal hurricane counts, December 2004.
- Anticipating Florida hurricanes, November 2004.

Use R for Climate Research: Tutorial

Use R for Climate Research Tutorial

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HurRisk Model

More Information

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http://garnet.fsu.edu/~jelsner/www

jelsner@fsu.edu
tjagger@blarg.net